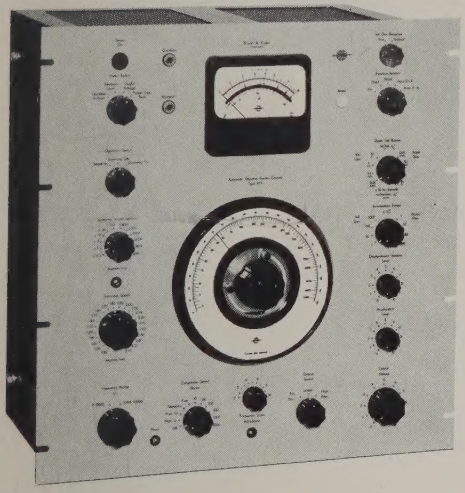
1019

SERVICE MANUAL



Automatic Vibration Exciter Control

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Automatic Vibration Exciter Control

Type 1019

JANUARY 1964

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1. Description

Instrument Functions.

The Automatic Vibration Exciter Control Type 1019 is made up from a variety of functional blocks but can be divided into two main sections:

1. A variable frequency sinusoidal signal generator section, and
2. A vibration measuring and feedback control section.

The functioning of the instrument and its uses are described fully in the Instructions and Applications manual supplied with the apparatus. A brief outline will therefore be sufficient here: The instrument is mainly used for automatic control of power amplifiers and associated shaker tables in various vibration tests. Section 1 supplies the variable frequency input signal to the power amplifier, while section 2 measures the vibration on the shaker table and, by forming a negative feedback loop, controls the output from section 1, thereby keeping either displacement, velocity or acceleration of the shaker table constant when the frequency is varied. The instrument has a built-in motor for automatic scanning of any predetermined part of the frequency range 5 c/s to 10 kc/s.

Section 1 is mainly an ordinary beat frequency oscillator and can of course be used as a sinuoidal signal generator in the frequency range 5 c/s to 10

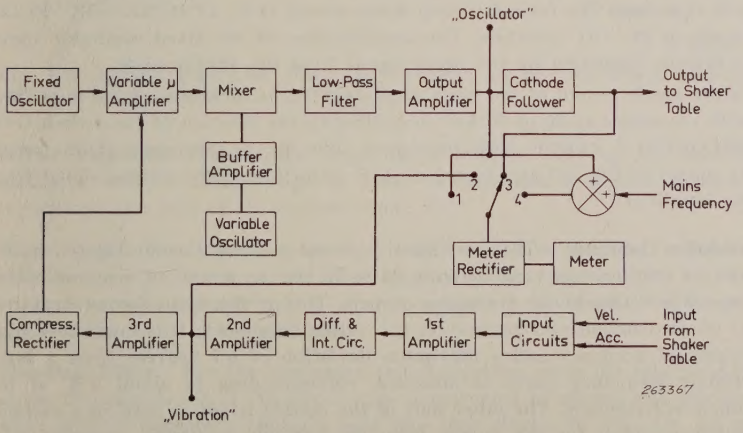

Fig. 1.1. Block diagram of the Automatic Vibration Exciter Control.

kc/s, while section 2, containing differentiating and integrating circuits, may be used for absolute measurement of vibration. The apparatus contains a moving coil instrument which can be switched to read either the r.m.s. output voltage from the signal generator section or peak values of acceleration, velocity or displacement from the vibration measuring section.

The 1019 is a fairly complicated piece of equipment. Whenever it is taken out of operation for servicing or adjustment it should be handled with great care, and should not be re-installed in an actual vibration test system until a complete check has indicated that the instrument is functioning properly.

Technical Description.

The various parts of which the instrument is made up will be described here, with reference to the block diagram in Fig. 1.1 and to the circuit diagram supplied with the instrument.

The Signal Generator Section.

Fixed Oscillator. The fixed oscillator is based on one half of the double triode V4, and works as a tuned plate oscillator at either 30 or 35 kc/s according to the position of the switch O 16. The other half of the double triode is connected in a cathode follower circuit for the output from the oscillator, ensuring minimum loading and consequently low distortion of the signal.

Variable-μ Amplifier. The output from the fixed oscillator section is fed to a variable-μ amplifier based on the pentode V 5. This pentode derives its grid bias from the feedback loop when switch O 17, COMPRESSOR SPEED, is not in its "Off" position. The amplification of the fixed oscillator signal is thereby regulated by the input signal from the shaker table.

In the anode circuit of the variable-μ amplifier is included a band-pass filter with resonance at 30 or 35 kc/s according to the position of the switch O 16, FREQUENCY RANGE. This band-pass filter has a frequency characteristic as shown in Fig. 1.2 and ensures a low distortion of the output signal from the amplifier.

Variable Oscillator. This oscillator is based on half the double triode V 6 and its frequency is variable from 25 to 30 kc/s by means of a motor driven capacitor C 130, in the resonance circuit. This is the main tuning capacitor of the instrument and determines the output frequency. It is made to a high degree of accuracy and a maximum deviation of 0.7 degrees from a logarithmic frequency curve is obtained, corresponding to about 3 % of the tuned-in frequency. The other half of the double triode is used in a cathode follower circuit for the output from the variable oscillator, ensuring minimum loading and low distortion of the output signal.

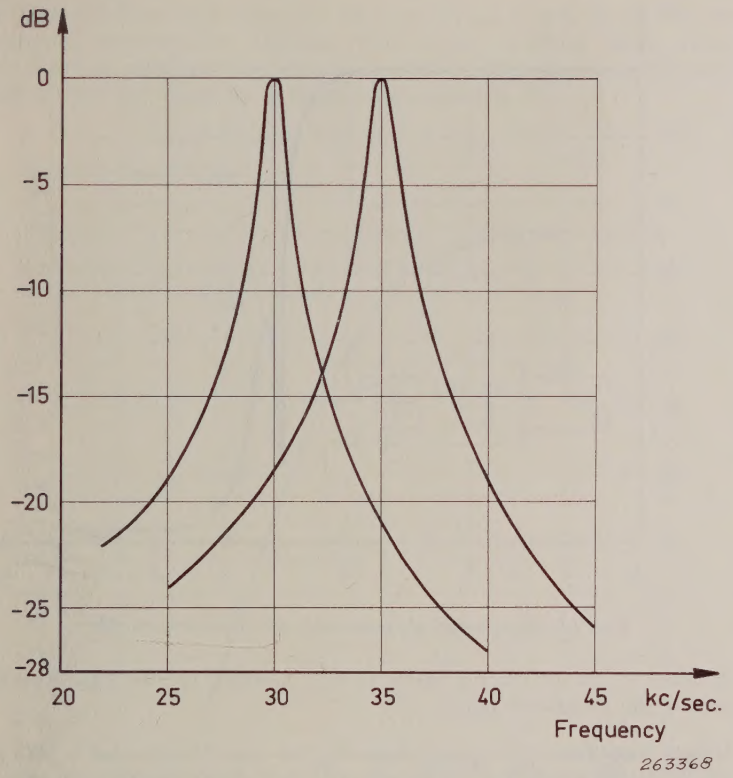

Fig. 1.2. Typical band-pass filter characteristic for the variable-μ amplifier section.

Buffer Amplifier. The buffer amplifier is inserted between the variable oscillator and the mixer stage in order to eliminate undesired feedback. It employs one half of the double triode V 7.

Mixer Stage. The signals from the buffer amplifier and the variable-μ amplifier are fed to the mixer stage, employing the other half of V 7. The triode type tube is employed in order to achieve a low hum level in spite of the AC heating of the filament.

Low-Pass Filter. The low frequency signal resulting from the superposition of the two signals fed to the mixer stage is extracted by means of a low-pass filter with a frequency characteristic like that shown in Fig. 1.3. As the frequency range of the instrument is 5 c/s to 10 kc/s the low-pass filter is

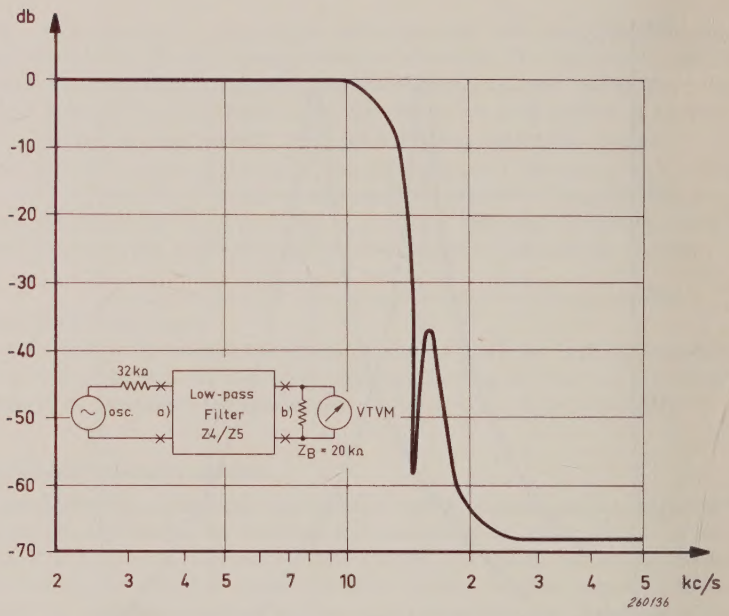

Fig. 1.3. Frequency characteristic for the low-pass filter.

designed to cut off sharply above 10 kc/s, blocking out the high frequency part of the modulated signal.

Output Amplifier. The signal from the low-pass filter is fed to the grid of the double triode V 8, which acts as a two stage amplifier. An external jack marked OSCILLATOR on the front panel is connected to the output amplifier when the OUTPUT SWITCH, O 24, is in position "Linear" or "High Pass", so that the output signal from the oscillator section can be monitored. The load impedance connected to the OSCILLATOR socket should be at least 500 kohm.

High-Pass Filter. The high-pass filter is switched in when the OUTPUT SWITCH is in position "High Pass" and may be used when vibration tests are carried out at constant displacement. The purpose of the filter is to extend the level range in which full regulation can be obtained for sudden changes in table load. This may be explained as follows: When the Automatic Vibration Exciter Control is switched to maintain a constant displacement level on the shaker table its output voltage must increase with frequency. If this steady increase in output voltage should only be taken care of by the regulating amplifier, the level range in which a sudden decrease in

vibration level could be regulated back to normal would decrease as the frequency increased. The high-pass filter in the oscillator output circuit will, however, automatically provide an output voltage increase of approximately 6 dB per octave up to frequencies around 25 c/s.

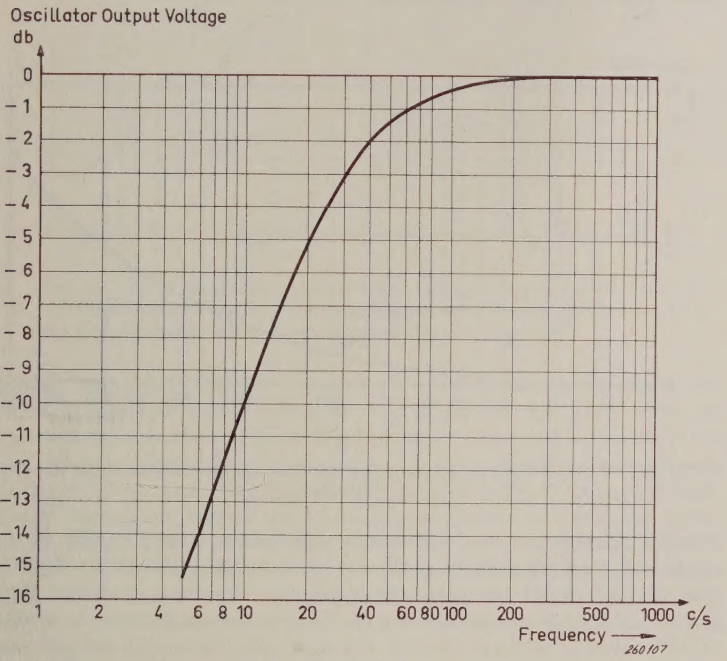

Fig. 1.4. Frequency characteristic for the high-pass filter.

Cathode Follower. The cathode follower output stage, V 9, is included in order to achieve a low output impedance from the oscillator section. The output from this cathode follower is taken to the socket marked OUTPUT at the back of the instrument. This is the main output which is used for driving the power amplifier for the shaker table. The load impedance should not be smaller than 10 kohm in parallel with 3 nF.

External Oscillator. An external oscillator may also be used instead of the built-in oscillator when the OUTPUT SWITCH, O 24, is in position "Ext. Osc.". The external signal is then fed via the socket marked OSCILLATOR on the front panel to the cathode follower input while the oscillator section of the Automatic Vibration Exciter Control is disconnected.

The Vibration Measuring Section (Feedback Network).

Input Circuits. With regard to the input signal from the shaker table there are two alternatives: The signal may either come from a velocity type pick-up, in which case it is applied to the socket marked VEL. GEN. INPUT at the back of the instrument, or from an acceleration pick-up with the signal applied to the socket marked ACC. GEN. INPUT.

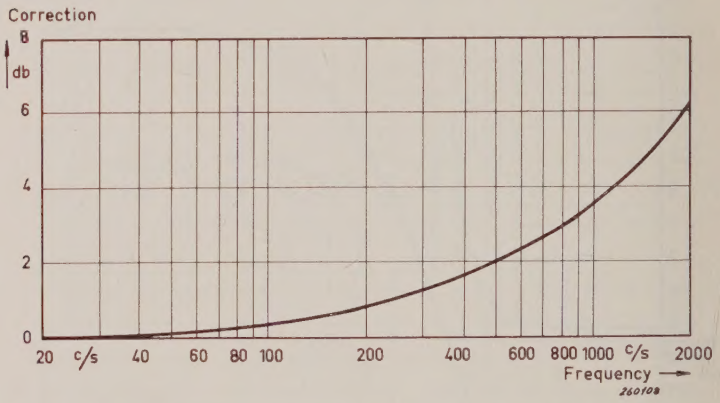

Fig. 1.5. Typical frequency response for the shaping network in the input circuit.

When a velocity pick-up is used the response may either be flat or it may be shaped, depending on the position of switch O 22, VEL. GEN. RESPONSE. The shaping circuit has a frequency response like that shown in Fig. 1.5, and is designed to compensate for the high frequency decrease in sensitivity of MB velocity pick-ups Models 124 and 126. The input circuits include integrating networks for a first integration of the input signal when deriving displacement from an acceleration signal. There are also several potentiometers for attenuation of the input signals according to the setting of the range switches, O 20 and O 21.

First Amplifier. The first amplification of the incoming signal takes place in the conventional R-C coupled amplifier based on the triode-pentode V 1. Due to the great dynamic range required from this amplifier an extensive smoothing and stabilization of the DC voltages has been found necessary. The stage amplification is adjusted with the potentiometer P 10 which controls the amount of feedback.

Differentiating and Integrating Circuits. The differentiating and integrating circuits are used when a further differentiation or integration of the signal is necessary for the instrument to perform its various functions.

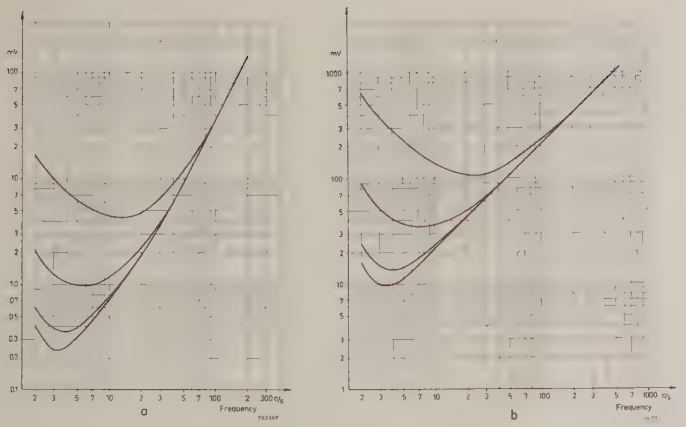

Fig. 1.6. Frequency characteristics for the stabilizing networks.
a) Displacement with acceleration generator. Range o.01".
b) Displacement with velocity generator. Range o.01".

Stabilizing Networks. Fig. 1.6, a and b show the frequency characteristics of the first amplifier stage, including the integrating networks, when the Automatic Vibration Exciter Control is set for constant displacement. It can be seen that the sensitivity of the stage at 5 c/s is 40 dB higher than the sensitivity at 50 c/s. Operating at higher frequencies a low frequency disturbance may consequently cause the closed loop consisting of oscillator, power amplifier, shaker table and vibration meter with servo to oscillate at a low frequency. To improve stability the frequency characteristic is therefore automatically changed into curve 2, 3 and 4 when the operating frequency is increased. This is achieved with the relays O 5, O 6 and O 7 operated from a switch on the tuning capacitor spindle.

Second Amplifier. From the first amplifier stage through the differentiating and integrating networks the signal is fed to the second amplifier stage which is based on the triode-pentode V 2. The stage is R-C coupled and employs a mixed voltage-current feedback. In order to block out low frequency noise from accelerometer, accelerometer cable and preamplifier, the amplifier is designed to provide a sharp cut-off at 5 c/s.
A protection diode is connected in the control grid circuit of the second tube and makes certain that no undesired blocking of the amplifier takes place even when, by accident, too large signals are applied to the vibration meter input. (Blocking of the amplifier might cause complete damage to the shaker and test specimen).
The output from the second amplifier is taken to a jack marked VIBRATION on the front panel of the instrument. This terminal may be used for

connection to a level recorder when a written record of the vibration on the shaker table or the test specimen is required. The load impedance at this terminal should preferably be at least 10 kohm. (70 kohm is already provided in series with the output jack). The output voltage is also taken to the METER SWITCH, O 23, so that vibration amplitude may be read off directly on the instrument meter, when the switch is in position "Vibration Level".

Third Amplifier. This amplifier stage consists of an ordinary amplifier and phase inverter based on the double triode V 3. The input voltage to the amplifier is controlled with the two potentiometers marked DISPLACEMENT-VELOCITY LEVEL and ACCELERATION LEVEL on the front panel (P 11 and P 5 on the circuit diagram).

The socket marked COMPRESSOR situated at the back of the instrument can be used for breaking into the third amplifier input circuit and thus give the compressor arrangement a special frequency characteristic. (Pins 1 and 5). It may also be used for connection of protective devices to safeguard the shaker and power amplifier. (Pins 2 and 3).

Compressor Rectifier. The output voltage from the third amplifier is rectified in a double diode rectifier. The time constant of the rectifier circuit is made variable, and the rectified voltage is used to control the working point of the variable-μ amplifier in the oscillator section, thus regulating the oscillator output voltage. By changing the time constant of the rectifier filter networks the speed with which regulation of the oscillator output takes place can be varied. This is done by turning the switch marked COMPRESSOR SPEED, O 17, and regulation speeds of approximately 10, 30, 100, 300, 1000 and 3000 dB/sec. are available. The regulation is furthermore a function of the actual amount of feedback. (See B & K Technical Review No. 2/1958).

During vibration tests the highest possible regulation speed should be used in order to prevent dangerous amplitudes from being built up in the system. However, when working at low frequencies with high compressor speeds, the compressor tends to regulate the waveform of the sinusoidally varying output signal from the Automatic Vibration Exciter Control, and this causes distortion of the signal.

Also, when the compressor speed is high and the Q-value of the specimen is high, there is a danger of the closed loop system being unstable and oscillations are developed in the set-up. This will be noticed as an amplitude modulation of the output from the oscillator section.

Due to these facts it has been found convenient to be able to increase the compressor speed automatically with frequency in order to reduce the low frequency distortion and at the same time to be able to take the expected Q-value of the specimen into account. Four automatic compressor speed

programs have consequently been built into the instrument in addition to the fixed compressor speeds mentioned above.

The compressor speed is changed by switching resistors into the compressor circuit. This can be done manually or, when an automatic program is employed, from a distributor switch on the main tuning capacitor spindle. in connection with the relays O 8, O 9, O 10, O 11 and O 12. The programs are pre-selected with the COMPRESSOR SPEED knob, O 17. In the table below are given the sequence of the automatic relay switching for the different settings of COMPRESSOR SPEED and the corresponding compressor speeds (dB/sec.).

Switch position \ Frequency range c/s	10—30	30—100	100—300	300—1000	1000—5000
High Q	None 10	None 10	None 10	O 8 30	O8 + O9 100
Med. Q	None 10	None 10	O 8 30	O8 + O9 100	O8 + O9 + O10 300
Standard	None 10	O 8 30	O8 + O9 100	O8 + O9 + O10 300	O8 + - - - + O11 1000
Fast	O 8 30	O8 + O9 100	O8 + O9 + O10 300	O8 + - - - + O11 1000	O8 + - - - + O12 3000

The Meter Circuit.

Meter Rectifier. The rectifier is a full wave quasi-r.m.s. rectifier which gives correct r.m.s. reading of any waveform with crest factor (V_{peak}/V_{rms}) lower than 3. This covers most waveforms met with in practice.

Frequency Calibration. The meter is used when calibrating the frequency dial on the front panel of the instrument. This is done by setting the METER SWITCH, O 23, to position 4, "Power Freq. Beat" and the frequency pointe. to the frequency of the mains or 1/5 thereof. The signal from the oscillator section is then sent through a non-linear circuit based on the transistor V 14, before being sent to the meter rectifier together with a signal from the power transformer. A beat is then observed on the meter resulting from the superposition of the mains frequency and the fundamental or fifth harmonic from the oscillator signal. The FREQUENCY SCALE ADJUSTMENT knob (C 132) is then adjusted until the meter pointer slows up and is only moving very slowly. If necessary the coarse adjustment (C 131, screwdriver operated) may also be used.

The Motor Drive.

The frequency scan of the oscillator section is driven by a reversible synchronous motor, the speed of which can be varied with the SCANNING

SPEED SELECTOR and the SCANNING SPEED switch, the total choice being 132 different scanning speeds, varying from 0.3 to 300 degrees/min. In addition there are six speeds for synchronizing the frequency sweep with the paper drive on the B & K Level Recorder Type 2305. (See Instruction Manual).

The motor of the Automatic Vibration Exciter Control is driven by pulses from two monostable multivibrators (ACY20 transistors) and these in turn are triggered by a unijunction transistor oscillator whose frequency is accurately controlled by the SCANNING SPEED SELECTOR and the SCANNING SPEED switch.

Cross-Over Relays.

The cross-over relays O 2, O 3 and O 4, are energized whenever acceleration is measured. They are controlled manually by setting FUNCTION SELECTOR to "Accel." or automatically from the relay O 13 which is energized by the cross-over switch on the tuning capacitor spindle when the FUNCTION SELECTOR is set to one of the "Auto." positions. The cross-over switch can be adjusted for closing anywhere between 8 and 1000 c/s.

Power Supply.

The power transformer has the following secondary windings:

7—8	300 V HT supply, rectified and accurately stabilized by two vacuum tubes and one gas-filled reference tube. A certain change in line voltage results in a HT level change of only one twentieth of this variation.
10—11—12	2 × 7 V. Rectified but not smoothed DC for energizing relays.
13—14	6.3 V for tube heaters.
15—16—17	2 × 9 V. Rectified, smoothed and stabilized DC for heaters of hum-susceptible tubes.
18—19—20	2 × 50 V. Rectified and smoothed for powering the transistorized motor control generator.
21—22—23	2 × 3.15 V for tube heaters.

2. Functional Check Procedure

Carrying out the following procedure will indicate whether the instrument is functioning properly or not, and if no discrepancies are found the Automatic Vibration Exciter Control may safely be installed in a vibration test set-up. It does not however check the absolute calibrations of the instrument, so that when a complete adjustment and checking program is found necessary, the procedure described in Chapter 3 should be followed.

Mains Voltage.

First of all make sure that the voltage selector at the back of the instrument is set to the correct mains voltage. If not, remove the fuseholder by turning it 1/4 turn anticlockwise and pulling out. Then set the selector to the correct mains voltage, using for example a small coin. Put the fuse back in position.

Calibration of Frequency Scale.

Set the various switches on the front panel as listed below. The switches that are not mentioned may be in any position.

POWER	"On"
OPERATION SWITCH	"Scanning Off"
OUTPUT SWITCH	"Linear"
COMPRESSOR SPEED	"Off"
FREQUENCY RANGE	"5—5000"
METER SWITCH	"Power Freq. Beat"

Move the adjustable cam discs at the rear end of the tuning capacitor spindle so that they are in line with the fixed disc.*)

Allow a few minutes warming up time.

1. When the frequency pointer is set exactly to the mains frequency a beat will show up on the meter. By turning the FREQUENCY SCALE ADJUSTMENT adjust the output frequency until the meter pointer slows up and almost stops. The meter swing should be approximately 10 dB.
2. Set the frequency pointer to one fifth of mains frequency and adjust again if necessary. The meter swing should be about 2 dB. Recheck at mains frequency.

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*) See "Partial Blocking of Frequency Scale Range" in Chapter 5 of the Instruction Manual.

Output Voltage.

Set the switches as follows:

METER SWITCH	"Output Voltage"
COMPRESSOR SPEED	"Off"
OUTPUT SWITCH	"Linear"
OPERATION SWITCH	"Scanning Off"

Switches not mentioned may be in any position.

1. With the OUTPUT VOLTAGE knob it should now be possible to get a deflection on the meter exceeding the upper limit of the scale, provided that the frequency pointer is on the calibrated part of the scale.
2. Adjust the deflection to 10 dB and switch COMPRESSOR SPEED to "High Q". The meter deflection should increase by some 8—10 dB.
3. Set

OUTPUT SWITCH to	"Linear"
COMPRESSOR SPEED	"Off"
FREQUENCY RANGE	"5—5000"

   Adjust for 19 dB deflection with the OUTPUT VOLTAGE knob and turn the frequency pointer slowly through the whole range. The meter deflection should not change by more than ± 0.5 dB.
   Repeat with FREQUENCY RANGE on "5005—10000". Maximum allowable change in meter deflection is now ± 1 dB.
4. Set OUTPUT SWITCH to "High Pass" and adjust for 20 dB meter deflection with the frequency pointer at 400 c/s. The output voltage should now decrease at lower frequencies:

At 100 c/s	— 0.3 dB ± 0.2 dB
5 c/s	— 15.0 dB ± 2.0 dB

Pick-up Amplifier Sensitivities.

A rough check on the amplifier sensitivities may be carried out with the instrument connected up as shown in Fig. 2.1. The accuracy of this check is usually sufficient when the instrument is used for vibration test set-ups, but when absolute measurement of vibration is carried out the procedure described in Chapter 3 should be followed. The figures given are approximate only but if too great deviations are found, the amplifier sensitivities should be adjusted as described in Chapter 3.

Displacement with Acceleration Generator.

Connect the OUTPUT at the back of the instrument to ACCEL. GEN. INPUT and VEL. GEN. INPUT as shown in Fig. 2.1 and set the various switches according to the following:

DISPLACEMENT-VELOCITY LEVEL	"10"

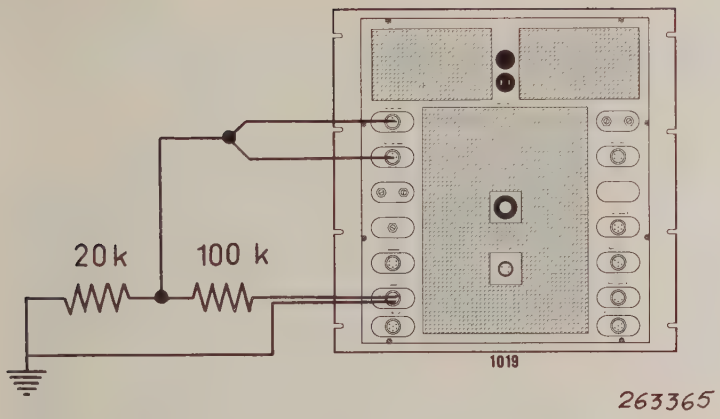


Fig. 2.1. Connection of voltage divider for checking amplifier sensitivities.

ACCELERATION LEVEL	"10"
METER SWITCH	"Output Voltage"
OPERATION SWITCH	"Scanning Off"
COMPRESSOR SPEED	"Off"
OUTPUT SWITCH	"Linear"
VEL. GEN. RESPONSE	"Flat"
FUNCTION SELECTOR	"Displ."
DISPL. VEL. RANGE	"0.01" (right hand side)
FREQUENCY RANGE	"5—5000"

Set the frequency pointer to 500 c/s and adjust the meter deflection to 5.4 V with the OUTPUT VOLTAGE knob. When the METER SWITCH is set to "Vibration Level" the meter should show approximately full deflection. Set the frequency pointer to 1000 c/s and check that the reading falls by approximately 12 dB.

Velocity with Velocity Generator.
Set the switches as follows:

DISPL. VEL. RANGE	"1" (left hand side)*)
METER SWITCH	"Output Voltage"
FUNCTION SELECTOR	"Vel."

The switches not mentioned should be left as in the previous test. Set the frequency pointer to 500 c/s and adjust the meter to read 4.1 V with the OUTPUT VOLTAGE knob. The meter should now read full scale when

*) Throughout the text the figures in quotation marks are those actually printed on the instrument front panel.

the METER SWITCH is set to "Vibration Level". Check that the reading does not change when the frequency range from 5—2000 c/s is scanned through.

Velocity with Acceleration Generator.

Set DISPL.-VEL. RANGE to "1" (right hand side)
METER SWITCH to "Output Voltage"

and adjust for a meter deflection of 3.8 V with the frequency pointer set to 500 c/s. Full scale deflection should now show up when the METER SWITCH is set to "Vibration Level". Check that the reading falls by 6 dB when the frequency pointer is set to 1000 c/s.

Displacement with Velocity Generator.

Set switches:

OUTPUT VOLTAGE	"0"
DISPL.-VEL. RANGE	"0.01" (left hand side)
FUNCTION SELECTOR	"Displ."
METER SWITCH	"Output Voltage"

Adjust the meter deflection to 6.4 V with the frequency pointer set to 500 c/s. The meter should now show full deflection when the METER SWITCH is set to "Vibration Level". Check that the meter deflection falls by 6 dB when the frequency pointer is set to 1000 c/s.

Acceleration with Velocity Generator.

Set switches:

OUTPUT VOLTAGE	"0"
FUNCTION SELECTOR	"Accel." (lamp will light)
ACCELERATION RANGE	"100" (left hand side)
METER SWITCH	"Output Voltage"

Adjust for an output voltage of 5.0 V at 500 c/s. This should give full deflection on the meter when the METER SWITCH is set to "Vibration Level". Check that the deflection falls by 6 dB when the frequency pointer is set to 250 c/s.

Acceleration with Acceleration Generator.

Set switches:

FUNCTION SELECTOR	"Accel."
ACCELERATION RANGE	"100" (right hand side)
METER SWITCH	"Output Voltage"

Adjust for 4.25 V deflection on the meter with the frequency pointer at 500 c/s. This should give full deflection on the meter when the METER SWITCH is set to "Vibration Level". Check that the deflection does not change appreciably when the frequency range from 10—10000 c/s is scanned through.

The Compressor Circuit (Feedback Network).

Connect OUTPUT (pin 1) at the back of the instrument to VEL. GEN. INPUT (pin 2), using a piece of cable with the appropriate plugs fitted. Set switches as follows:

COMPRESSOR SPEED	"100"
FUNCTION SELECTOR	"Vel."
DISPL.-VEL. RANGE	"10" (left hand side)
METER SWITCH	"Vibration Level"
OUTPUT VOLTAGE	"10"
OUTPUT SWITCH	"Linear"

1. With the frequency pointer at 200 c/s the DISPLACEMENT-VELOCITY LEVEL knob is adjusted so that the meter deflection is 18.7 dB. DISPL.-VEL. RANGE is then switched to "o.1" on the left hand side. The meter deflection should not change by more than + 1.3 dB.

2. Turn OPERATION SWITCH to "Stand By". The meter deflection should immediately fall to zero and come back without overshoot when OPERATION SWITCH is returned to "Scanning Off".
   Repeat this with DISPL.-VEL. RANGE set back at "10". The same conditions should hold.

3. Set DISPL.-VEL. RANGE to "10"
   COMPRESSOR SPEED "Standard"
   METER SWITCH "Vibration Level"
   Adjust the meter deflection to 19 dB with the DISPLACEMENT-VELOCITY LEVEL and scan the frequency range 5—2ooo c/s. The meter reading should not change by more than ± o.5 dB.

4. Meter deflections from — 2 to + 21 dB should be obtainable by turning DISPLACEMENT-VELOCITY LEVEL.
   Connect the output to ACC. GEN. INPUT at the back of the instrument and set

FUNCTION SELECTOR	"Accel."
ACCELERATION RANGE	"1ooo" (right hand side)
METER SWITCH	"Vibration Level"
COMPRESSOR SPEED	"Standard"
OUTPUT VOLTAGE	"10"

   Adjust the meter deflection to 19 dB with the ACCELERATION LEVEL knob and scan the frequency range from 10 c/s to 10 kc/s. The meter deflection should not change by more than ± o.5 dB.
   Meter deflections from — 2 to + 21 dB should be obtainable by turning ACCELERATION LEVEL.

3. Complete Check and Adjustment Procedure

The following procedure checks the instrument functions and calibrations and includes the items of chapter 2.
The whole procedure or parts thereof should be carried out whenever it has been found necessary to replace any of the major components of the instrument, or when the instrument is not working according to its specifications. It is assumed that the instrument is not connected to any other vibration equipment while checks are carried out.

Mains Voltage.
First of all make sure that the voltage selector at the back of the instrument is set to the correct mains voltage. If not, remove the fuse holder by turning it 1/4 turn anticlockwise and pulling out. Then set the selector to the mains voltage using for example a small coin. Put the fuse back in position.

Internal Voltage Levels.
To check the internal voltage levels set the switches as follows:

POWER	"On"
FREQUENCY RANGE	"5—5000"
COMPRESSOR SPEED	"Standard"
FUNCTION SELECTOR	"Vel."
OPERATION SWITCH	"Scanning On"
DISPL.-VEL. RANGE	"0.01" (left hand side)*)
VEL. GEN. RESPONSE	"Flat"
METER SWITCH	"Vibration Level"
OUTPUT SWITCH	"Linear"
SCANNING SPEED SELECTOR	"X 0.3"
SCANNING SPEED	"1.00"
OUTPUT VOLTAGE	"10"

Allow a few minutes warming-up time.

Connect a beat frequency oscillator to VEL. GEN. INPUT at the back of the instrument (pin 2) and adjust the input to be 6.81 mV, 400 c/s with the aid of a precision voltmeter. The meter should now show full scale deflection.

*) Throughout the text the figures in quotation marks are those actually printed on the instrument front panel.

Set the METER SWITCH to "Output Voltage" and adjust for approximately 10 V deflection on the meter by turning up the DISPLACEMENT-VELOCITY LEVEL. (Since the compressor is working, the voltage level may build up slowly and may also be rather unstable because the system is not a closed loop).

The Automatic Vibration Exciter Control is now set up with all its major components working, and the voltages given on the circuit diagram should be checked, with due regard to the fact that DC potentials may exist at the measuring points, so that a large blocking capacitor should be used if not incorporated in the voltmeter. Also check the DC voltages marked on the vacuum tube base diagrams.

The voltages given are approximate only and deviations as high as 20 % may be tolerated.

Replace any tube or component that is found to be defective.

Frequency Characteristic of Cathode Follower (V 9).

Set the switches as follows:

OUTPUT SWITCH	"Ext. Osc."
OUTPUT VOLTAGE	"10"
OPERATION SWITCH	"Scanning Off"

Connect a precision signal generator (beat frequency oscillator) to the jack marked OSCILLATOR on the front panel. With a vacuum tube voltmeter connected to the OUTPUT at the back of the instrument, check that the frequency characteristic is linear to within $\pm$ 0.2 dB from 5 to 10000 c/s. At 0.5 c/s the tolerance is $\pm$ 2 dB. The input voltage should be 8 to 10 V.

Meter Sensitivity and Damping.

Switch the power off and set

OUTPUT SWITCH	to	"Linear"
METER SWITCH	to	"Oscillator Voltage"

With a 10 V calibrated input signal of about 400 c/s connected to the OSCILLATOR jack, the meter deflection should be adjusted to exactly 10 V with the screwdriver operated potentiometer marked METER at the back of the instrument (P 15).

With a 5 c/s input signal the meter swing should be about 1° and at 2 c/s the swing should be rythmically constant, otherwise one of the rectifier diodes is defective.

Meter Frequency Characteristic.

Check the frequency characteristic of the meter by varying the input frequency from 5 c/s to 10 kc/s and keeping the input voltage constant with a precision voltmeter. The meter reading should not change by more than $\pm$ 1 %.

Adjustment of Oscillator Voltage.

Disconnect the external oscillator and switch the power on again. Set switches as follows:

METER SWITCH	"Output Voltage"
OUTPUT SWITCH	"Linear"
COMPRESSOR SPEED	"Off"

Turn the PHASE potentiometer (P 12) on the front panel fully anticlockwise with the aid of a screwdriver. Connect a precision vacuum tube voltmeter across R 92 in the output amplifier grid circuit and adjust for 320 mV r.m.s. with the two potentiometers P 2 and P 3 for the two frequency ranges. (For component location, see Chapter 4). At 5000 c/s the voltage across R 92 should be exactly the same for both frequency ranges.

Output Voltage.

With the switches set as above check that a meter deflection of more than full scale is obtainable by turning up the OUTPUT VOLTAGE knob.

Adjust the meter deflection to 10 dB and switch COMPRESSOR SPEED to "High Q". The output voltage should now increase by something in the order of 10 dB.

Set METER SWITCH to "Power Freq. Beat" and the frequency pointer to exactly the mains frequency. FREQUENCY RANGE on "5—5000". A beat should show up on the meter. Adjust the FREQUENCY SCALE ADJUSTMENT until the beat slows up and almost stops. If necessary use the screwdriver operated coarse adjustment located beneath the knob. The meter swing should be in the order of 10 dB.

Set the frequency pointer to one fifth of the mains frequency and repeat the procedure. The meter swing should now be about 2 dB.

The frequency scale of the instrument is now calibrated.

Frequency Characteristic of Output Voltage.

Set the switches as follows:

OUTPUT SWITCH	"Linear"
METER SWITCH	"Output Voltage"
COMPRESSOR SPEED	"Off"

Adjust for 19 dB meter deflection with the OUTPUT VOLTAGE knob and scan the frequency range from 5 to 5000 c/s. The meter deflection should not vary by more than ± 0.5 dB. Repeat for the range 5005 to 10000 c/s. Tolerance ± 1 dB.

Set the OUTPUT SWITCH to "High Pass" and adjust for 20 dB deflection at 400 c/s. The output voltage should now decrease at lower frequencies:

At 100 c/s	— 0.3 dB ± 0.2 dB
5 c/s	— 15.0 dB ± 2.0 dB

Pick-up Amplifier Sensitivity.

Note: Before adjusting the sensitivities as described below, make sure that the standard instruments used are properly calibrated. It is particularly important that the input signal is free from distortion.

Always set the frequency pointer of the Automatic Vibration Exciter Control to the frequency of the input signal, in order to ensure that the correct stabilizing networks are working.

Displacement with Acceleration Generator.

Set the switches as follows:

VEL. GEN. RESPONSE	"Flat"
DISPLACEMENT-VELOCITY LEVEL	"10"
ACCELERATION LEVEL	"10"
FUNCTION SELECTOR	"Displ."
DISPL.-VEL. RANGE	"o.01" (right hand side)
METER SWITCH	"Vibration Level"

Connect a beat frequency oscillator, an electronic counter and a precision vacuum tube voltmeter to the ACC. GEN. INPUT at the back of the instrument (pin 2) and adjust the input to be exactly 904 mV, 500 c/s. The meter deflection should now be exactly full scale. If it is not, adjust with the potentiometer P 10, marked DISPL./A.G. at the back of the instrument. (The sensitivity may be set 1.5 % higher or lower if it facilitates the adjustment for 5 c/s below).

Set DISPL.-VEL. RANGE to "1" and the frequency pointer to somewhere below 30 c/s. With a 5 c/s input signal the meter should show 4 % below full deflection for an input voltage of 9.04 mV. If not, adjust with potentiometer P 4.

Velocity with Velocity Generator.

Connect the signal generator and voltmeter to VEL. GEN. INPUT and switch FUNCTION SELECTOR to "Vel.". Set DISPL.-VEL. RANGE to "o.01" (left hand side). With an input signal of 6.81 mV, 500 c/s, the meter should show full scale exactly. If not, adjust with the potentiometer P 6, marked VEL./V.G. at the back of the instrument.

When the input frequency is varied from 5 to 2ooo c/s the meter deflection should not vary by more than $\pm$ 2 %.

Velocity with Acceleration Generator.

Connect the signal generator and voltmeter to ACC. GEN. INPUT and switch FUNCTION SELECTOR to "Vel.". Set DISPL.-VEL. RANGE to "o.1" (right hand side). Full deflection on the meter should now be obtained with an input signal of 57.6 mV r.m.s. at 500 c/s. The sensitivity may be adjusted with potentiometer P 9, marked VEL./A.G. at the back of the instrument.

Displacement with Velocity Generator.
Connect the signal generator and voltmeter to VEL. GEN. INPUT and switch FUNCTION SELECTOR to "Displ.". Set DISPL.-VEL. RANGE to "o.01" (left hand side). Full deflection on the meter should be obtained with an input signal of 1070 mV at 500 c/s. The sensitivity may be adjusted with potentiometer P 8, marked DISPL./V.G. at the back of the instrument.

With all the switches as in the previous test adjust the input voltage for full deflection on the meter at 30, 100 and 300 c/s and check that the deflection does not change more than 1 % when the stabilizing relays are energized at these frequencies. (The relays are activated by a distributor switch on the tuning capacitor spindle).

Set the input signal and the frequency pointer of the Automatic vibration Exciter Control to 10 c/s and adjust for full deflection with the switches set as in the previous test. There should now be a fall in sensitivity when the frequency pointer of the Automatic Vibration Exciter Control is moved upwards:

FREQUENCY C/S	10	50	150	400
FALL IN DEFLECTION DB	0	o.5—1	4.5—6	16—19

Switch FUNCTION SELECTOR to "Accel." and set ACCELERATION RANGE to "1" (left hand side). Full deflection on the meter should be obtained with an input signal of 8.38 mV at 500 c/s. The sensitivity may be adjusted with the potentiometer P 7, marked ACCEL./V.G. at the back of the instrument.

Repeat the adjustment for "Displacement with Velocity Generator" above since the two potentiometers P 7 and P 8 influence each other.

Acceleration with Acceleration Generator.
Connect the signal generator and precision voltmeter to ACC. GEN. INPUT and switch FUNCTION SELECTOR to "Accel.". Set ACCELERATION RANGE to "1" (right hand side). Full deflection on the meter should correspond to an input signal of 7.07 mV r.m.s. at 500 c/s. The sensitivity may be adjusted with potentiometer P 13, marked ACCEL./A.G. at the back of the instrument. Check that the sensitivity does not change more than $\pm$ 2 % between 10 and 10ooo c/s.

Velocity Generator Response.

Connect the signal generator to VEL. GEN. INPUT and switch FUNCTION SELECTOR to "Vel.". With VEL. GEN. RESPONSE on "Flat" adjust the meter deflection to 10 dB with DISPL.-VEL. RANGE on "o.1" say. (Left hand side). Then switch VEL. GEN. RESPONSE to "Shaped" and vary the

input frequency from 10 c/s to 2000 c/s. The following increase in sensitivity should be observed:

Frequency c/s	Increase dB	Frequency c/s	Increase dB
10	0	700	2.58
100	0.26	800	2.92
200	0.83	900	3.15
300	1.24	1000	3.52
400	1.63	1250	4.16
500	1.94	1500	4.80
600	2.30	2000	6.19

Compressor.

Switch COMPRESSOR SPEED to "Off" and connect the signal generator to the COMPRESSOR input at the back of the Automatic Vibration Exciter Control (Pin 5). With an input voltage of about 0.7 V, 400 c/s adjust P 1 until the AC voltages on the anodes of V 3 are equal. Remove the signal generator.

Connect the OUTPUT at the back of the instrument to VEL. GEN. INPUT and set the switches as follows:

COMPRESSOR SPEED	"100"
FUNCTION SELECTOR	"Vel."
DISPL.-VEL. RANGE	"10" (left hand side)
METER SWITCH	"Vibration Level"
OUTPUT VOLTAGE	"10"

Set the frequency pointer to 200 c/s and adjust DISPLACEMENT-VELOCITY LEVEL until a meter deflection of 18.7 dB is obtained. Switch DISPL.-VEL. RANGE to "0.1". The meter deflection must not increase by more than 1.3 dB.

Set DISPL.-VEL. RANGE to "10" and adjust meter deflection to 10 dB. When OPERATION SWITCH is set to "Stand by" the output voltage should disappear immediately and come back without overshoot in position "Scanning Off". Repeat for all positions of COMPRESSOR SPEED.

Set DISPL.-VEL. RANGE to "10" and adjust meter deflection to 10 dB. Switch DISPL.-VEL. RANGE to "0.1". When OPERATION SWITCH is set to "Stand by" the output voltage (Vibration Level) should disappear immediately and return without overshoot in position "Scanning Off". Repeat for all positions of COMPRESSOR SPEED.

Repeat the last test by braking and making the contact at the back of the tuning capacitor spindle instead of using the OPERATION SWITCH.

Compressor Speeds.

Check by moving the frequency pointer manually that the compressor relays are energized according to the following table when COMPRESSOR SPEED is set to the positions indicated.

Switch Position \ Frequency Setting c/s	15	50	150	500	1500
High Q	None	None	None	O8	O8 + O9
Med. Q	None	None	O8	O8 + O9	O8 + O9 + O10
Standard	None	O8	O8 + O9	O8 + O9 + O10	O8 + - - - + O11
Fast	O8	O8 + O9	O8 + O9 + O10	O8 + - - - + O11	O8 + - - - + O12
10	None				
30	O8				
100	O8 + O9				
300	O8 + O9 + O10				
1000	O8 + O9 + O10 + O11				
3000	O8 + O9 + O10 + O11 + O12				

Compressor Frequency Characteristic for Velocity Operation.

Keeping the OUTPUT connected to VEL.-GEN. INPUT set the switches as follows:

FUNCTION SELECTOR	"Vel."
COMPRESSOR SPEED	"Standard"
DISPL.-VEL. RANGE	"10" (left hand side)
METER SWITCH	"Vibration Level"
OUTPUT VOLTAGE	"10"
OUTPUT SWITCH	"Linear"

Adjust the meter deflection to 19 dB with DISPLACEMENT-VELOCITY LEVEL and scan the frequency range from 5 to 2000 c/s. The meter deflection should not vary by more than ± 0.5 dB.

Meter deflections from —2 to +21 dB should be obtainable by turning DISPLACEMENT-VELOCITY LEVEL.

Compressor Frequency Characteristic for Acceleration Operation.

Connect the OUTPUT to the ACC. GEN. INPUT and set the switches as follows:

FUNCTION SELECTOR	"Accel."
ACCELERATION RANGE	"1ooo" (right hand side)
METER SWITCH	"Vibration Level"
COMPRESSOR SPEED	"Standard"
OUTPUT VOLTAGE	"10"
OUTPUT SWITCH	"Linear"

Adjust the meter deflection to 19 dB with ACCELERATION LEVEL and scan the frequency range from 10 c/s to 10ooo c/s. The change in meter deflection should be less than ± o.5 dB.

Meter deflections from — 2 to + 21 dB should be obtainable by turning ACCELERATION LEVEL.

Motor Speeds.

In order to adjust the pulse repetition period for the synchronous drive motor set SCANNING SPEED SELECTOR to "X1" and SCANNING SPEED to "1.80". Connect an amplifier and electronic counter to pin 3 of the socket SWEEP CONTROL B at the back of the instrument. Adjust the periodic time of the impulses to 24 m.sec. by turning the potentiometer P 14, marked MOTOR at the back of the instrument.

For frequency synchronization with the B & K Level Recorder the six right hand positions of SCANNING SPEED SELECTOR should be used. The following periodic times should be observed:

SWITCH POSITION	o.864	2.59	8.64	25.9	86.4	259
PERIODIC TIME m.sec.	50.00	18.67	5.00	55.54	16.66	5.554

Any necessary adjustment is done with the screwdriver operated potentiometer located underneath the SCANNING SPEED SELECTOR.

4. Mechanical Details

Removal of Tuning Capacitor CV 0009.

Should it become necessary to remove the tuning capacitor in order to reach inaccessible components, the following procedure applies:

Remove the right hand side cover (when seen from the instrument front plate) of the capacitor unit CV 0009. Then turn the tuning spindle until the capacitor blades are fully interleaved. Check the alignment of the blades by holding a perfectly plane instrument across them. The scale pointer should now point at 220°. **If not, then carefully note down the position of the pointer.**

Disconnect the capacitor electrically by removing the multi-plugs at the back and unsoldering the two leads to the coil cans. Unscrew the two knobs on the tuning spindle and remove the scale rim, pointer and scale. The four screws which secure CV 0009 to the front plate can then be unscrewed and the capacitor unit taken out of the apparatus.

After replacing the scale, center it with reference to the spindle by means of a centering bush and set the pointer to exactly 220° for fully interleaved capacitor blades or to the position noted above.

Motor Unit.

The motor unit can be taken out without disturbing the tuning capacitor unit CV 0009. The meter and scale lamp are removed first, allowing the motor unit to be separated from CV 0009 and lifted up through the hole in the upper chassis. The four securing screws are accessible through holes in the CV 0009 back plate. By removing the cams at the back and the four screws that hold the back plate, the back plate can be pulled away and turned to one side exposing the magnetic clutch, gears and switch mechanism for automatic compressor speed changing.

Front Plate.

In order to avoid ground loops the front plate of the instrument is isolated from the chassis.

Rack Mounting.

When the instrument is mounted in a rack, especially in the case of mobile test units, it is advisable to use more fixing points than those in the front plate. Two holes have therefore been drilled and tapped in each side and in

the bottom plate of the housing, and these should be used as extra fixing points. It is then necessary to isolate the screws from the rack for example by insulating bushings, in order to keep the front plate isolated from the instrument chassis.

Component Location.

The following tables should be used in connection with the photographs on pp. 30—40 and the circuit diagram for easy location of electrical and mechanical components.

Capacitors

No.	Fig.	No.	Fig.	No.	Fig.
C1	4.6	C26	4.5	C85	4.6
C2	4.6	C27	4.6	C86	4.2
C3	4.2	C29	4.6	C87	4.6
C4	4.2	C30	4.6	C88	4.6
C5	4.2	C42	4.6	C89	4.4
C6	4.2	C44	4.6	C100	4.9
C7	4.2	C50	4.1	C101	4.4
C8	4.2	C51	4.1	C102	4.6
C9	4.2	C52	4.2	C103	4.5
C10	4.5	C60	4.5	C104	4.6
C11	4.4	C61	4.5	C105	4.5
C12	4.4	C62	4.5	C107	4.6
C13	4.1	C63	4.8	C108	4.4
C14	4.2	C64	4.4	C109	4.5
C15	4.6	C65	4.4	C111	4.9
C16	4.6	C68	4.6	C112	4.9
C17	4.5	C69	4.2	C113	4.5
C18	4.4	C70	4.10	C114	4.1
C19	4.1	C71	4.8	C118	4.9
C20	4.4	C72	4.1	C119	4.3
C21	4.2	C73	4.1	C120	4.4
C22	4.2	C80	4.6	C121	4.2
C23	4.1	C81	4.5	C122	4.6
C24	4.4	C83	4.5	C123	4.2
C25	4.5	C84	4.1	C131	4.5

Resistors

No.	Fig.	No.	Fig.	No.	Fig.
R1	4.5	R48	4.6	R114	4.5
R3	4.6	R49	4.6	R117	4.8
R4	4.1	R61	4.6	R118	4.6
R5	4.5	R63	4.3	R121	4.10
R6	4.1	R64	4.6	R122	4.9
R11	4.5	R65	4.6	R123	4.5
R13	4.7	R66	4.6	R125	4.7
R15	4.1	R67	4.6	R126	4.8
R16	4.5	R70	4.6	R127	4.6
R18	4.5	R75	4.5	R129	4.10
R19	4.4	R76	4.6	R130	4.9
R20	4.5	R77	4.5	R131	4.8
R21	4.5	R78	4.5	R132	4.9
R22	4.5	R79	4.5	R133	4.8
R23	4.4	R80	4.7	R135	4.10
R24	4.5	R82	4.5	R137	4.5
R26	4.5	R83	4.5	R138	4.5
R27	4.5	R84	4.9	R139	4.6
R28	4.5	R85	4.6	R140	4.6
R29	4.5	R86	4.8	R141	4.10
R30	4.6	R88	4.6	R142	4.10
R32	4.5	R89	4.5	R143	4.6
R33	4.4	R91	4.3	R144	4.8
R34	4.4	R93	4.9	R145	4.6
R35	4.6	R95	4.10	R184	4.9
R36	4.6	R96	4.8	R185	4.7
R37	4.1	R98	4.4	R186	4.7
R39	4.4	R99	4.6	R187	4.7
R40	4.1	R100	4.6	R200	4.2
R41	4.6	R102	4.6	R201	4.5
R42	4.4	R108	4.5	R202	4.4
R43	4.6	R109	4.5	R203	4.2
R44	4.6	R110	4.6	R204	4.2
R45	4.5	R111	4.9	R206	4.7
R46	4.4	R112	4.8		
R47	4.5	R113	4.5		

Switches and Relays

No.	Fig.	No.	Fig.	No.	Fig.
O1	4.1	O8	4.10	O15	4.3
O2	4.4	O9	4.10	O16	4.3
O3	4.4	O10	4.10	O17	4.5
O4	4.4	O11	4.10	O18	4.2
O5	4.2	O12	4.10	O19	4.3
O6	4.2	O13	4.1	O23	4.2
O7	4.2	O14	4.10	O24	4.5

Potentiometers

No.	Fig.	No.	Fig.	No.	Fig.
P1	4.4	P6	4.1	P12	4.1
P2	4.1	P7	4.1	P13	4.1
P3	4.1	P8	4.1	P14	4.1
P4	4.6	P9	4.1	P15	4.1
P5	4.4	P10	4.1	P16	4.4

Valves

No.	Fig.	No.	Fig.	No.	Fig.
V1	4.2	V5	4.5	V9	4.3
V2	4.2	V6	4.5	V10	4.2
V3	4.2	V7	4.4	V11	4.2
V4	4.5	V8	4.5	V12	4.2

Diodes

No.	Fig.	No.	Fig.	No.	Fig.
Q2	4.4	Q16	4.8	Q26	4.7
Q3	4.4	Q17	4.8	Q27	4.7
Q4	4.3	Q18	4.10	Q28	4.3
Q5	4.3	Q19	4.10	Q29	4.3
Q6	4.3	Q20	4.10	Q30	4.3
Q7	4.3	Q21	4.10	Q31	4.3
Q12	4.6	Q22	4.10	Q32	4.11
Q13	4.3	Q23	4.10	Q33	4.3
Q14	4.10	Q24	4.7		
Q15	4.8	Q25	4.7		

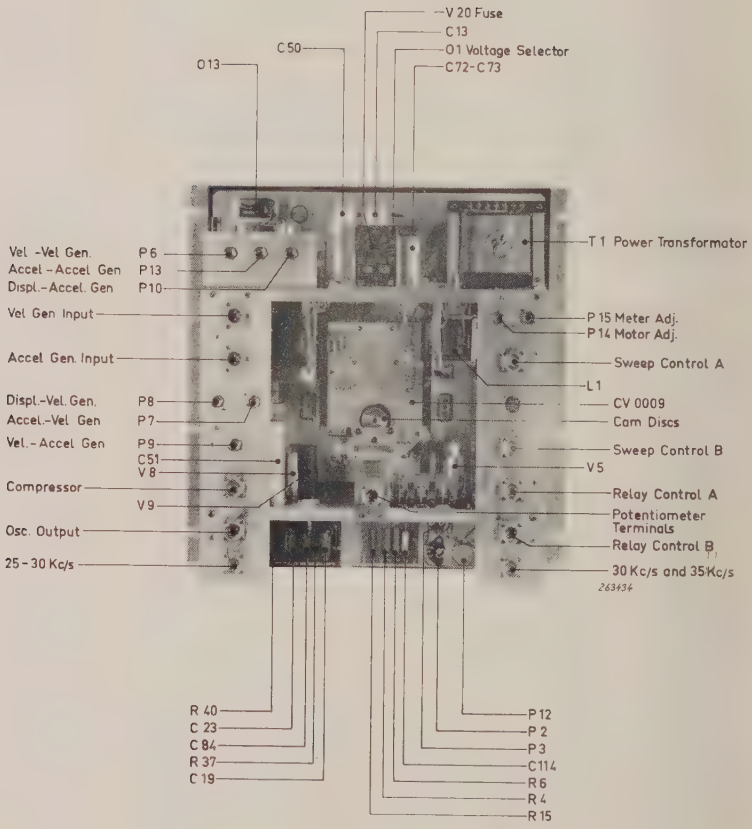


Fig. 4.1. The Automatic Vibration Exciter Control seen from behind.

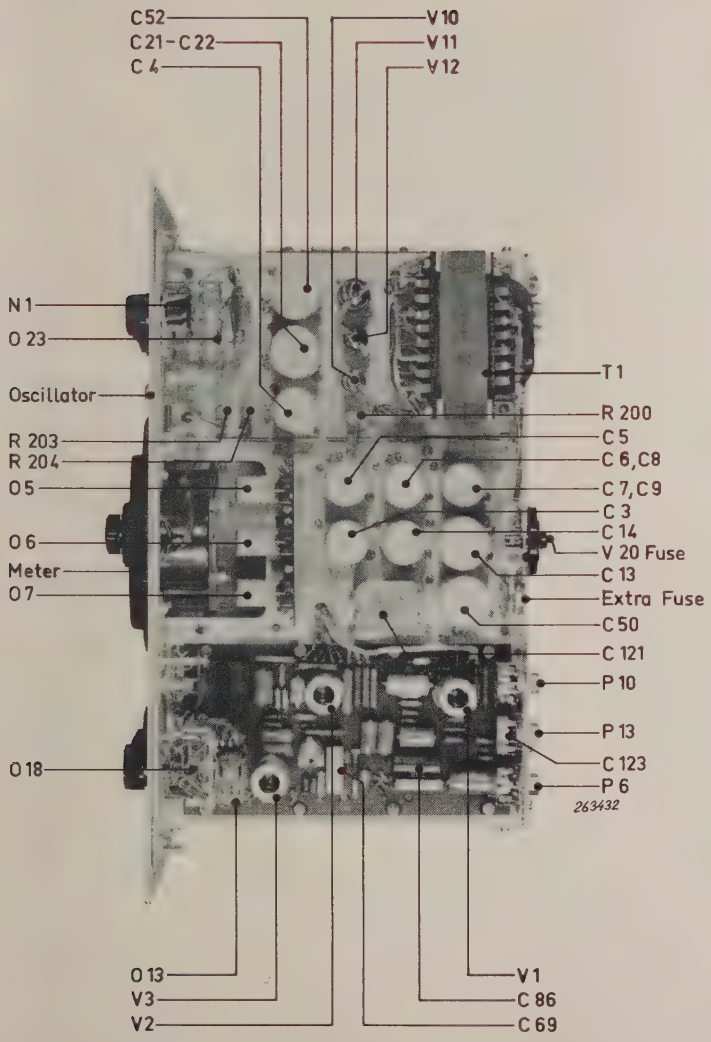


Fig. 4.2. Top view of the Automatic Vibration Exciter Control. See also Fig. 4.6.

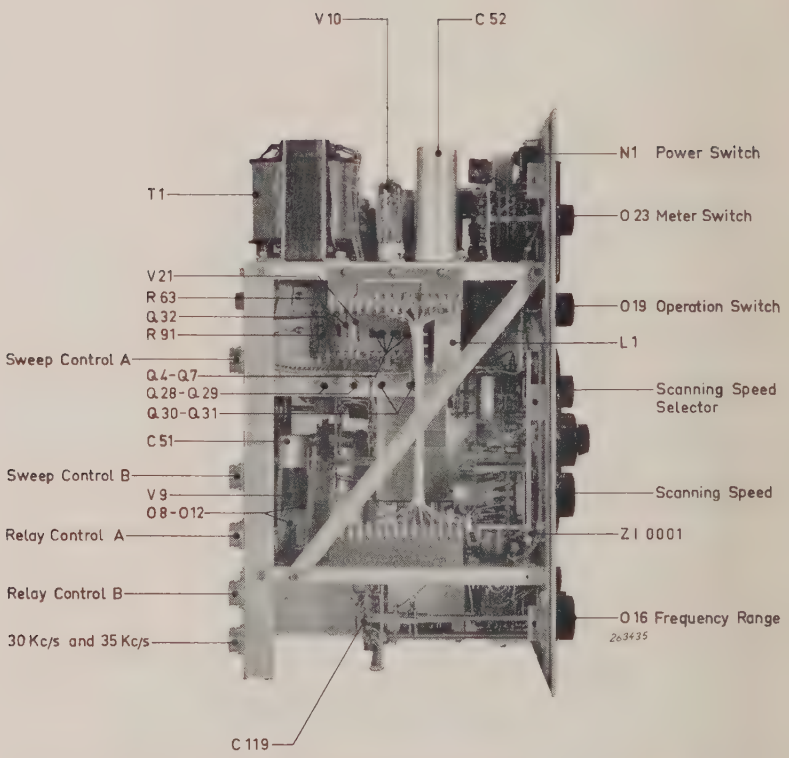


Fig. 4.3. The Automatic Vibration Exciter Control seen from the right hand side.

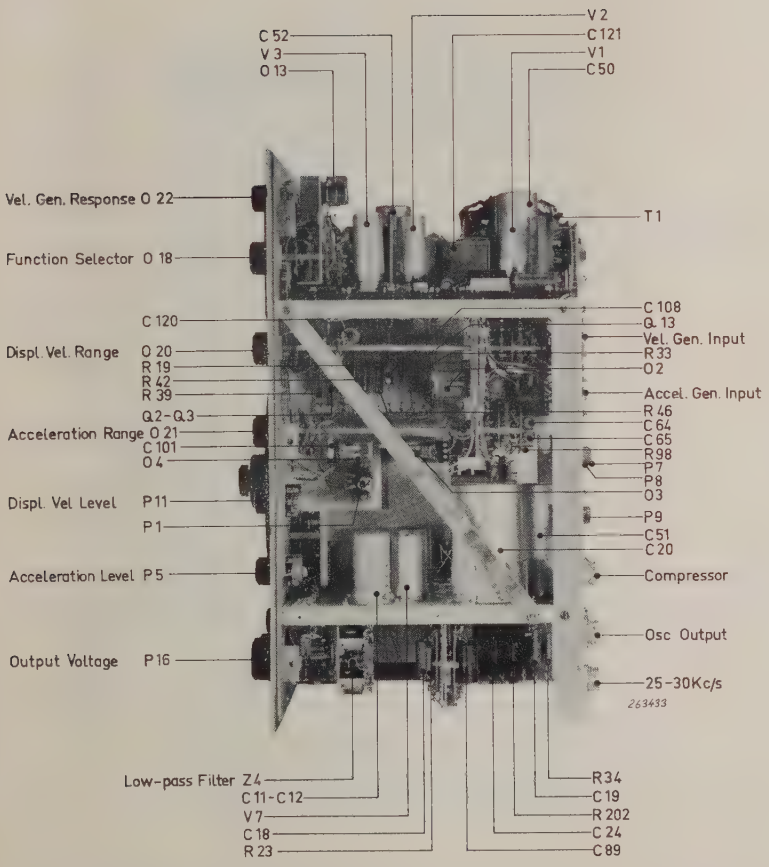


Fig. 4.4. The Automatic Vibration Exciter Control seen from the left hand side.

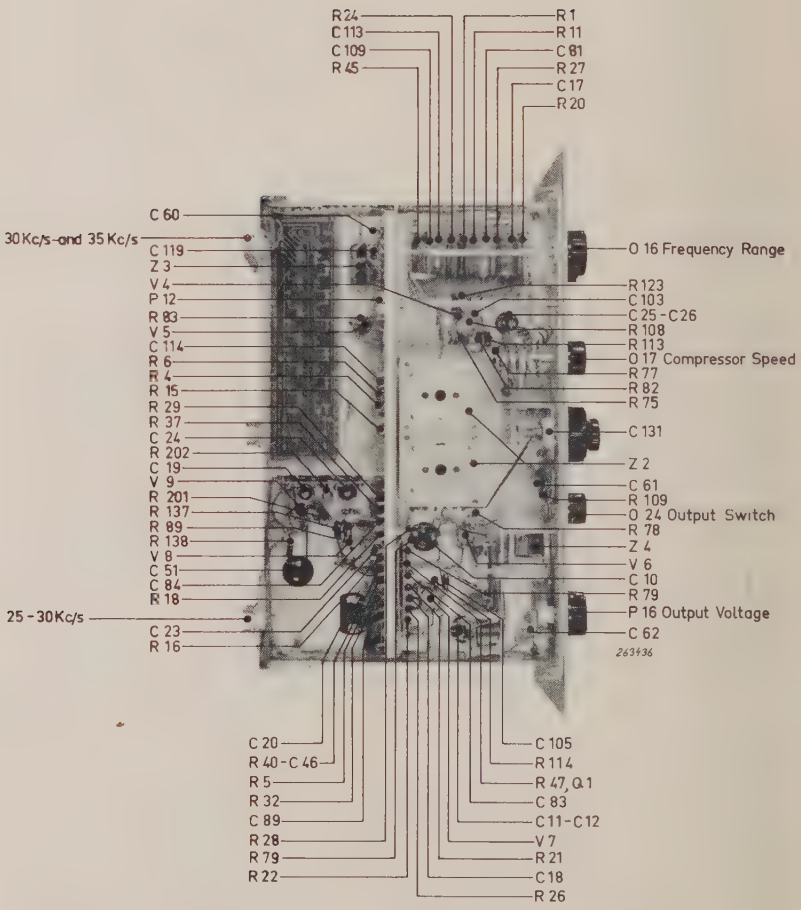


Fig. 4.5. Bottom view of the Automatic Vibration Exciter Control.

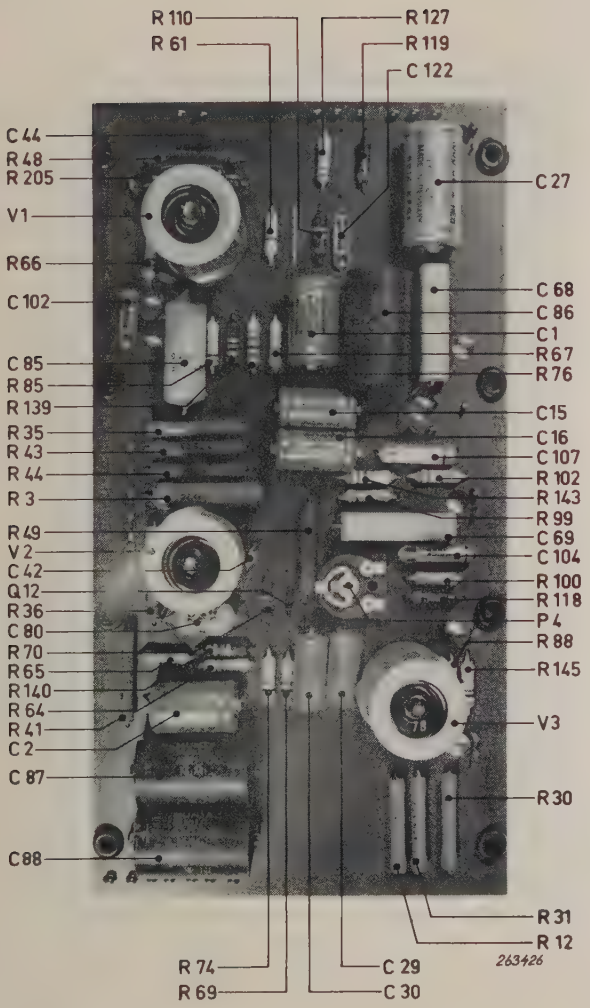


Fig. 4.6. Close-up of part of the input amplifier section. See Fig. 4.2.

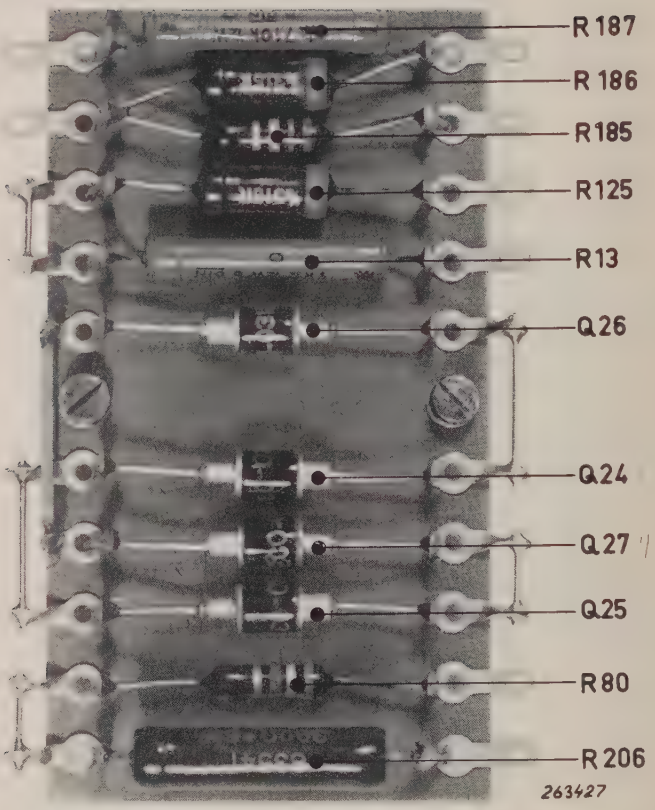


Fig. 4.7. Close up of part of the power rectifier circuit.

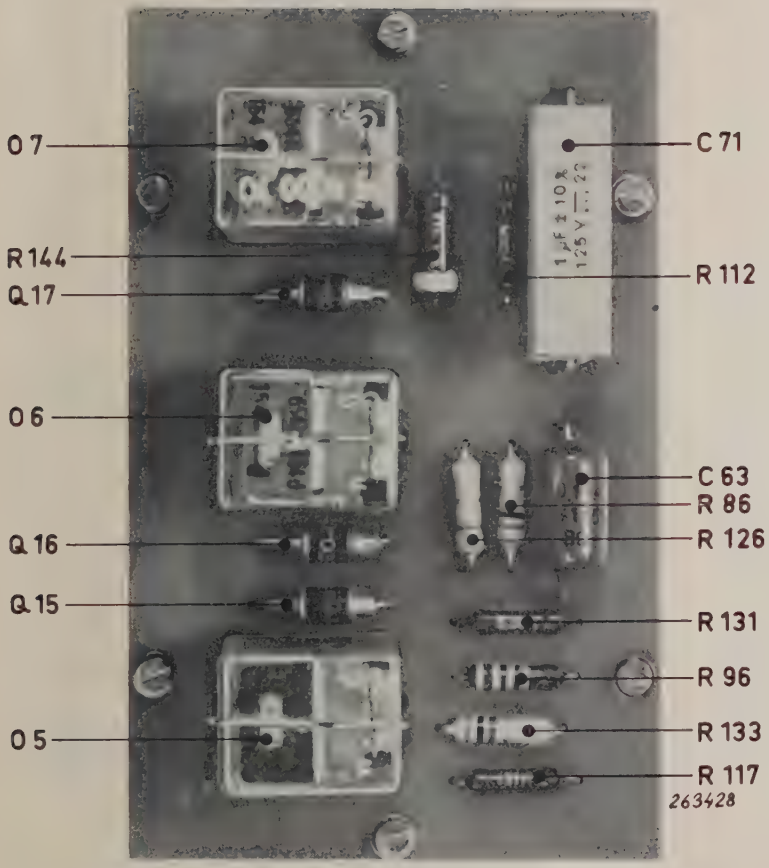


Fig. 4.8. Close-up of the stabilizing relays in the differentiating and integrating circuits.

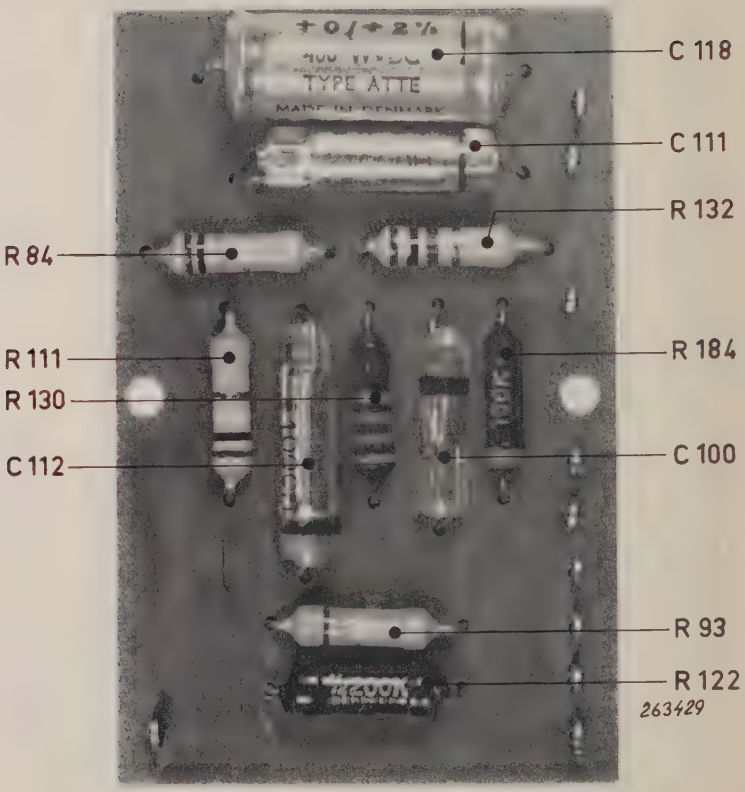


Fig. 4.9. Part of the first input integrating circuits.

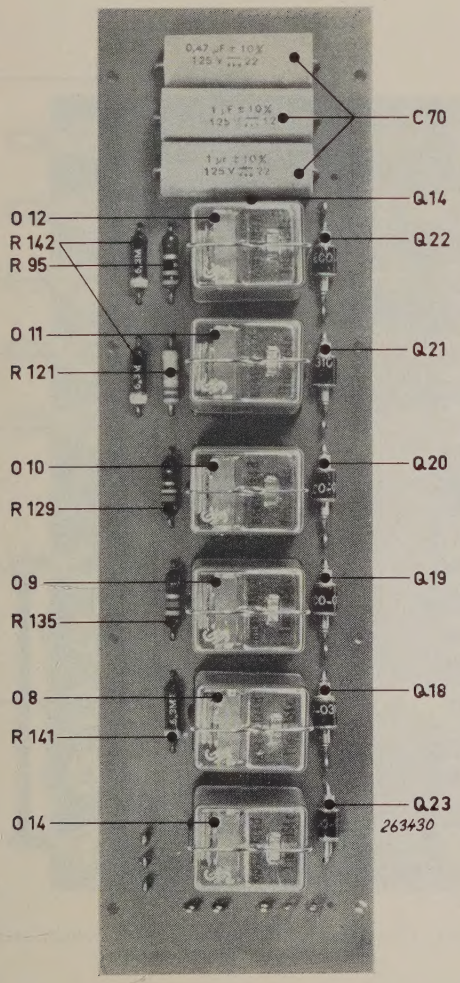


Fig. 4.10. Close-up of the compressor speed relays.

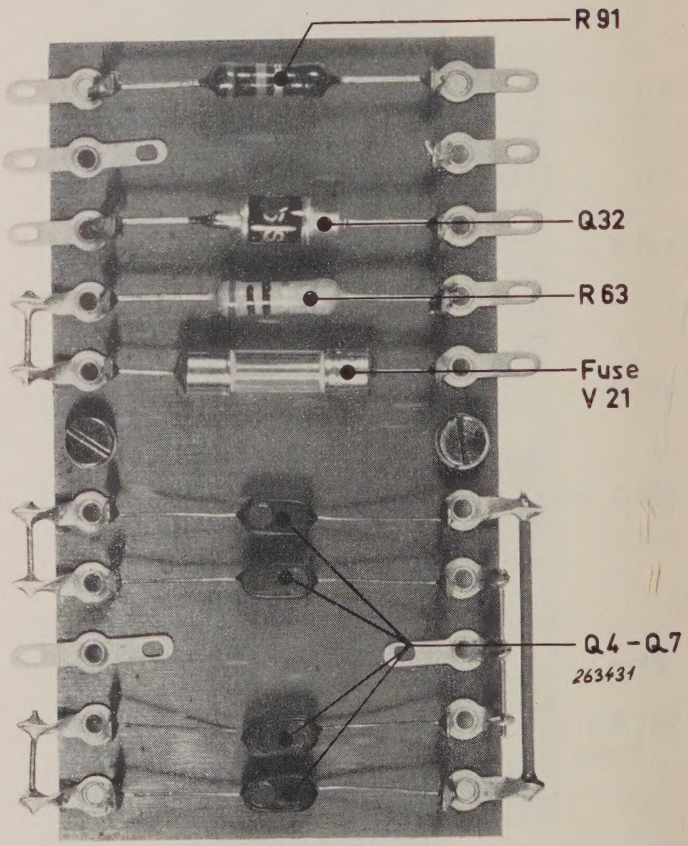
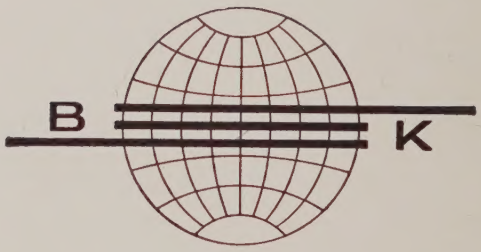


Fig. 4.11. Close-up of part of the power rectifier circuit.



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